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CONFINEMENT REARING of CATTLE

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Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

ABOUT THIS REPORT........

Numerous inquiries regarding confinement of beef and dairy cattle received by ARS reflect widespread producer interest. This report is written to supply county agents and other farm leaders with information on research related to confinement production of beef and milk.

No studies have been conducted by ARS on confinement as such, but considerable work has been done on many aspects of livestock production involved in confinement. Among the related subjects investigated to some extent by ARS or the State Agricultural Experiment Stations and included in this report are the following:

Environment, particularly (1) the effect of climatic variables such as air temperature, humidity, air movement, and thermal radiation on the performance of cattle; (2) measures for alleviating the adverse effect of climatic extremes on livestock; and (3) adjusting rations to extreme climatic conditions.

Facilities, including buildings, layout, and equipment, water and manure disposal with particular reference to their importance in confined cattle enterprises.

Each major section of the report is followed by a list of a few pertinent publications, some by USDA, some bulletins published by State Agricultural Experiment Stations with USDA scientists cooperating, and some building plans for farm structures and equipment issued under the Cooperative Farm Building Plan Exchange. Most of these publications can be obtained from the Information Division, ARS, U.S. Department of Agriculture, Hyattsville, Md., 20781, or from the State Agricultural Experiment Stations. The detailed building plans are obtainable only through the State Extension Agricultural Engineers at the Land Grant Colleges.

Information for this report was provided by the Agricultural Engineering Research and Animal Husbandry Research Divisions, Agricultural Research Service.

CONFINEMENT REARING OF CATTLE

In recent years, an increase in confinement of beef and dairy cattle for the economic production of milk and beef has taken place. Growth in the size of operations, increased specialization, the need to save on labor, rising cost of land adjacent to cities, new developments in feeding, and the competitive need to lower unit production costs have all contributed to this.

WHAT'S INVOLVED IN CONFINEMENT

For purposes of this report, confinement means any operation in which the cattle are taken off pasture and have their feed brought to them in a confined area. This includes beef animals that are fed in a drylot and dairy cattle that are fed and milked without access to pasture under a loose housing system or in a drylot as well as in stanchion barns.

Confinement involves many important aspects of milk and beef production. Climatic environment of the animals, buildings, farmstead layout, equipment, and feed all have an important bearing on the efficiency of beef and dairy enterprises using confined cattle. Since confined animals are taken off pasture, for example, harvesting forage crops at their peak and processing and storing them so as to maintain the maximum nutritive value are important.

Confinement increases the importance of protecting livestock from communicable diseases and harmful parasites but at the same time increases the opportunity for utilizing protective measures. The close proximity of the animals could increase the speed with which disease organisms spread. Constant vigilance against admitting any diseased or parasite-infested animals or contaminated materials into the confined area and maintenance of accepted sanitary standards are necessary. It is especially important that animals that show suspicious symptoms be immediately isolated in sick pens and promptly examined by a veterinarian. On the other hand, routine and systematic use of precautionary measures, such as frequent inspection for any signs of contagious diseases, vaccination against communicable diseases, treatment for grubs, and periodic spraying of all animals against harmful parasites and insects is simpler and surer under confinement conditions than when the livestock are scattered. Some of the larger commercial feedlots have staff veterinarians on duty at all times. This and their good restraining facilities and sanitary programs are believed to be largely responsible for the low animal death rate in well-managed feedlots.

ARS has no studies aimed specifically at confinement as such but has conducted many studies independently and in cooperation with the States to develop criteria applicable to confinement of various kinds of livestock.

ENVIRONMENTAL CONSIDERATIONS

Studies have shown that the rate of gain of beef cattle and milk production of dairy animals is significantly affected by the animal's environment. Cattle use their feed more efficiently in producing meat and milk when environmental conditions are favorable.

The various climatic factors, such as air temperature, relative humidity, velocity of air currents, and thermal radiation, are of major importance in their effect on animal gains and productivity. Performance of confined cattle may also be affected favorably or adversely by the amount of space allotted to them, by accessibility of feed and water, exposure to insect pests, the presence of other animals, and other external conditions.

The growing practice of confining large numbers of animals to a relatively small space has increased the opportunity and need for controlling the animal's environment to achieve greater efficiency in the production of meat and milk. In some cases, confinement may even make a degree of environmental control necessary for efficient production. This follows partly from the fact that the more narrowly animals are restricted, the less able they are to move to a more comfortable environment.

Two major types of questions face the beef producer and the dairyman in planning for a favorable environment for his animals: (1) What particular factors in the environment affect the production efficiency of beef and dairy animals most importantly and what combinations of environmental conditions are favorable to efficient production? (2) How can the environment of confined animals best be improved in a particular instance--and is the expense economically justified in production savings?

Microclimate

As anyone who has moved from a stuffy spot to a breezy one will readily realize, an animal's responses are affected by the climate immediately surrounding it, rather than by the general climatic conditions prevailing over a wide area. This "little" climate around the animal is known as its microclimate. For this reason, ARS and State livestock specialists and agricultural engineers have been concerned with the various elements that make up the microclimate and how they affect the performance and productivity of dairy and beef cattle. In addition to prevailing climatic conditions of the area, other variables such as terrain, design and placement of buildings, their color, presence or absence of shade, proximity of water, type of fences, and height of the animal affect its microclimate. Presence or absence of other livestock also affect the microclimate, since livestock dissipate large amounts of heat into their surroundings.

Animal Responses--General

The climatic environment affects the direction and rate at which heat moves between cattle and their surroundings by the four general methods of heat transfer: convection, conduction, evaporation, and radiation.

The reason cattle, in common with humans and other warmblooded animals, are so affected by their climatic environment is that their well-being and survival require a rather delicate balance between the heat produced by their body and heat gained from or lost to their environment. Extreme temperatures, either above or below the normal comfort zone, make it more difficult for the cattle to maintain a constant body temperature. For this reason exposure to extreme temperatures is likely to cause temperature stress, accompanied by lowered productivity.

Cattle tend to adjust to climatic extremes by decreasing their feed consumption when the weather is hot and increasing their consumption when it is cold. This affects the amount of heat generated by the animals, since about one-third of the feed consumed by cattle is converted to heat during the digestive process. The amount of heat generated is also affected by the type of feed, being greater for roughage than for high protein concentrates. (See page 10.)

Temperatures to which beef and dairy animals adjust satisfactorily differ greatly from the wider temperature range comfortable to man. Experimental evidence to date suggests that the comfort zone of European breeds of cattle lies within the temperature range of approximately 30° to 75° F. However, the various cattle breeds and individuals within the particular breed vary widely in their ability to tolerate heat and cold.

When environmental conditions are favorable, the normal rectal temperature of cattle is around 101° F. Temperature of Holstein, Jersey and Brown Swiss dairy cows remained normal at air temperatures as low as 0° F. in experiments conducted by USDA and State researchers at the University of Missouri. However, body temperatures increased rapidly as air temperatures went above 80° F. As air temperatures reached 105° F., body temperatures of the cattle went as high as 108° F.

Animal Responses to Climatic Variables

The search for precise knowledge of how cattle respond to their climatic environment is complicated by the fact that the climate is composed of many varying elements. This makes it difficult to separate and measure the effect on livestock of one particular climatic variable. Air temperature, relative humidity, airflow, and thermal radiation are among the significant elements of the climatic environment that have been studied in relation to their influence on livestock performance.

Air Temperature

Among the climatic variables affecting gains of beef cattle, temperature of the surrounding air is probably the most important as well as the most easily measured.

For some breeds, gains may become slower as temperatures rise above 75° F. In experiments made at the University of Missouri in cooperation with USDA researchers, Shorthorn calves gained about 1/2 pound more weight per day at 50° than at 80° F. temperature. And in Federal-State cooperative studies in the Imperial Valley of California, Hereford cattle gained 0.36 lb. more per day when they had access to shelter cooled 7° F. below the high outside temperature.

Cattle do not utilize feed as efficiently to produce beef when the temperature of the air surrounding them is significantly higher or lower than the rather narrow range of temperatures experimentally established as the comfort zone of the breed. In the Missouri studies, the efficiency with which Shorthorn cattle converted feed to gains was reduced by high environmental temperatures. At 50° F., the cattle required 4.88 pounds of total digestible nutrients per pound of gain as compared to 5.37 pounds at 80° F. Somewhat more feed was also required to manufacture a pound of meat when the surrounding temperature was significantly below optimum. If it is too cold, the animal has to use a larger part of its feed to maintain its body temperature. However, the more heat-tolerant Brahmans were slightly more efficient in conversion at 80° than at 50° F.

Extreme temperatures also affect milk production of dairy cows adversely. Holstein cows apparently can adapt to temperatures as low as 10° F. without loss of production, while Jersey production dropped off at 30° F. On the other hand, Jerseys appeared to be somewhat more tolerant of heat than Holsteins, although both breeds suffered severe production losses as temperatures increased above 75° F. At 80° F., Holstein production had dropped about 10 percent below normal and at 90° F. production was reduced about 35 percent.

At one time 50° to 60° F. was recommended as optimum temperature for housing dairy cattle where economically feasible. However, research since this recommendation was made indicates that the optimum condition for dairy cattle includes a wider range of temperatures between 30° to 75° F., with a slight advantage in feed conversion credited to holding the temperature near 75° F.

Investigations have also been directed at finding the effect of average daily temperature of the surrounding air on livestock as distinguished from constant temperatures used in early laboratory experiments. In a cooperative Federal-State experiment conducted at the Missouri Agricultural Experiment Station, dairy cattle reacted to day-night variation in temperatures in much the same way as if the temperature were constant at the average of the day-night variation. Thus a daily temperature range of 50° to 110° F. had less adverse effect on milk production than daily temperatures ranging between 70° to 100° F., because the average temperature was lower in the former situation.

In addition to its direct effect on livestock comfort and performance, air temperature has significant indirect effects. Air movement, relative humidity, the temperature of other objects in the animal's vicinity and consequently the heat radiation from such objects are all affected by air temperature. And all in turn affect the animal's heat losses and gains.

Relative Humidity

Although the amount of moisture in the air appears to have little effect on milk production at temperatures between 17° and 75° F., high relative humidity aggravates the adverse effect of higher air temperature on milk production. In cooperative ARS-State experiments at the Psychroenergetic Laboratory of the University of Missouri, milk production dropped only 3 percent at 85° F. with a 44-percent relative humidity but decreased by 31 percent at the same temperature with a 90-percent relative humidity.

Recent studies of the effect of various combinations of temperature and relative humidity on dairy cows have shown a definite relationship between the Temperature-Humidity Index and milk production. This index is a scale of temperature and relative humidity combinations adopted by the U.S. Weather Bureau as a "Discomfort Index" for measuring the effect of the various temperature-humidity combinations on human comfort.

By thus relating the cow's milk production efficiency at various temperature-humidity levels to a single base point on the Discomfort Index Scale, researchers believe they have made progress toward reducing the number of variables that need to be considered in seeking more precise answers to animal environment problems.

Airflow

Increasing the air movement speeds up evaporative heat losses when the air is unsaturated. Although cattle are not classed as sweating animals like horses and man, they do lose considerable water through their skins. By speeding up evaporation of moisture on the animal's skin, accelerating the flow of unsaturated air around the animal causes more rapid cooling.

Velocity of the air also affects the rate at which an animal exchanges heat with the surrounding atmosphere through convection. Whether the animal gains or loses heat convectively depends on whether the temperature of the surrounding air is higher or lower than the animal's surface temperature.

Increasing air velocity may also indirectly affect radiant heat by increasing or decreasing the temperature of objects surrounding the animal.

Value of providing adequate airflow around cattle during hot weather has been demonstrated in laboratory tests and under farm and feedlot conditions. In the Imperial Valley, for example, cooperating USDA and California scientists found that cattle in wooden pens made higher daily gains when the normal breeze was bolstered from around 1/2 mile per hour to around 4 miles per hour by means of electric fans. In 1955, fanned cattle increased their daily gains by 1.03 pounds over unfanned cattle.

Another way of increasing air movement around livestock is to avoid placing any obstructions, such as buildings and wooden fences, between the natural summer breezes and the animals. A cooperative experiment in the Imperial Valley showed that the average summer air velocity was 0.77 miles per hour in a wood corral as compared to 2.4 miles per hour in a wire corral located in the same general location. When fans were used in wire corrals where the wind was 2.4 miles per hour, no benefit to cattle was noted. This suggests that there is probably little or no advantage in using fans to increase the airflow when it is normally this high or higher. Findings also emphasize the superiority of open or well ventilated shades and shelters and wire fences for animals during hot weather.

Thermal Radiation

Thermal radiation is another important variable in the environment which affects heat losses and gains of cattle--and consequently their comfort and performance.

In daylight, the sun is the greatest source of radiant heat on the landscape. But other objects in the environment radiate energy at different rates, depending on the emissivity and the temperature of the energy-emitting surface.

When the objects around an animal become warmer, its radiant heat load is increased. When its surroundings become cooler, its radiant heat load is decreased or its heat losses increased.

By cutting off the direct rays of the sun, shade trees and artificial shades can reduce the amount of radiant energy reaching animals, while leaving them exposed to the cool northern sky. Exposure to the cool sky may in turn contribute to the warm-weather comfort of the animals by serving as a cool sink into which the animals can radiate their body heat. This is particularly true in clear, dry areas.

Although it is difficult to separate the effect of thermal radiation from temperature, velocity, and relative humidity of the surrounding air, heating and air-conditioning engineers have concluded that radiation is as important as convection (the transfer of heat to the air as the air moves over the object) in establishing the rate of heat loss from the body. For example, a room with a 68° F. air temperature and 68° F. wall temperature and one with a 59° F. air temperature and a 77° F. wall temperature would be equally comfortable.

Other experiments have shown that the conditions under a white-painted aluminum roof are cooler than under unpainted aluminum because the white reflects more of the sun's rays.

Methods of Alleviating Unfavorable Climatic Conditions

Possibilities for reducing the adverse effect of extreme climatic environment on beef and dairy cattle have been investigated in a number of field and laboratory studies by USDA and the various States. Because of the many variables involved, practices found useful in one area or one set of circumstances are not necessarily helpful or practical in another. But information developed in these studies provides a scientific basis for protecting livestock from cold or heat stress under widely varying conditions through the use of well designed shelters and shade, adequate ventilation, use of water for sprinkling or cooling, and, where economically practicable, by supplementary heating or cooling systems.

Shelters

Since shelters are primarily built to protect housed animals from climatic extremes, they accomplish their basic purpose only to the extent that they provide an environment favorable to optimum livestock performance.

To properly design a livestock shelter for any given locality requires knowledge of the basic weather picture as well as knowledge of what climatic environment would be favorable for the animal.

Weather data collected by the U.S. Weather Bureau at more than a hundred stations and published in 5-year summaries provides basic information useful to engineers in determining the degree of enclosure, amount of insulation--if any--required, and the structural strength needed to withstand stress from snow and wind.

As differences in microclimate may be great between adjacent spots, the variations need to be taken into account in selecting the site for shelters and shades. Knowledge in this area is limited but research is seeking more precise methods of measuring microclimate.

The degree of enclosure that the shelter should provide is determined by the immediate climatic environment and the desired environment of the animals to be protected. Although much more still needs to be learned about environmental requirements of beef and dairy cattle for optimum performance, research findings to date have been helpful in designing buildings adapted to more efficient production of milk and beef.

Evidence that extremely hot temperatures have more adverse effect on the performance of beef and dairy cattle than do low temperatures has tended to place more emphasis on open construction and good ventilation for shelters in hot and moderate areas. An exception would be fully closed, insulated buildings equipped with air conditioning which have been used under special circumstances by some farmers when economically feasible.

Shades

Providing adequate shade to protect cattle from solar radiation is among the more important and widely used devices for improving the environment of cattle in hot climates. Tests have shown that the radiant heat load on an animal can be reduced by as much as 30 to 50 percent by shading it.

With shades, as with other livestock facilities, the requirements and benefits vary with conditions. In California and Kansas, beef cattle made better gains under properly constructed shades. But consistent benefits from the use of shades for beef or dairy cattle have not been proved in experiments in Tifton, Ga.

Cooperative Federal-State experiments in the Imperial Valley of California show that cattle there are cooler under shelters that are high enough to permit free circulation of the air and exposure to the cool northern sky. A height of 10 to 12 feet is recommended in this hot, dry, and usually cloudless area. For Louisiana, on the other hand, the recommended height of shades is 6 to 8 feet. Tests there have not shown an economic advantage in the higher shades under Louisiana conditions, possibly because the radiation is less severe or because the northern sky is cloudier and warmer there than in the clear West--and, so, less capable of absorbing heat radiated from the cattle.

The California experiments also showed that the temperature stress on animals may be further reduced by orienting the shades in an East-West direction to give maximum exposure to the northern sky. However, a north-south orientation promotes better sanitary conditions by admitting enough sun to help dry the accumulated manure and urine and thus reduce the problem of flies, odors, and disease.

Hay or straw was found the most effective of some 50 possible roofing materials or combinations of materials tested in California for providing cool shade. Aluminum also rated high as a cool roofing material while snow fencing tested lowest on the list.

Recommendations for shades in feedlots did not apply to areas immediately around feed bunks or at water troughs. Shades in feeding and watering areas encourage animals to congregate there, increasing the likelihood that a mudhole will develop and feed and water will become contaminated. However, animals were found to eat better when feed was placed relatively near to shade than when they were compelled to travel considerable distance in the hot sun to feed bunkers.

At the University of Arizona, for example, cattle gained about 1/3 pound more a day and used less feed per pound of gain when their shade was located 10 feet away from their feed bunker than when the shade was 54 feet distant from the bunker.

In deciding for or against shades as with other improvements, the farmer obviously needs to weigh the costs against the value of the probable production gains resulting from the shade. Amount of shadow space required by each animal is an important item in cost. In recent studies aimed at getting more precise information about the minimum shade requirements of animals, investigators concluded that 25 to 30 square feet of shade per animal would be adequate for summers in the Imperial Valley.

Ventilation and Air Conditioning

Providing adequate ventilation is essential for maintaining a favorable climatic environment in livestock shelters. In fact, optimum humidity and optimum temperature are major objectives in livestock shelter ventilation design.

As cattle dissipate rather large amounts of water as vapor, barns become very humid unless they are well ventilated. High humidity is not only detrimental to animal health and comfort but hastens feed spoilage and building deterioration. Generally a range of 55 to 75 percent relative humidity is considered optimum for dairy barns. Proper ventilation is also important for maintaining a temperature that is favorable to maximum production and is comfortable for the farmer. Although milk production remains high at temperatures down to 20° F., keeping the temperature above 32° F. is generally desirable to prevent the barn water system from freezing. Importance of designing and placing shelters and shades to get maximum airflow under high temperature conditions has already been noted in this report, as has the fact that high humidity increases the adverse effect of high air temperatures on cattle.

Two other objectives of ventilation design are the removal of odors and providing fresh air. Generally moisture removal is the primary aim in dairy shelter ventilation design, since the other objectives are in most cases automatically met when this is achieved.

Of the three major types of ventilating systems, mechanical ventilation with fans and blowers is the most popular. It provides positive air control, is readily adapted to automatic control, and is better adapted to one-story buildings than is the gravity-type system. Although gravity ventilation systems using outlet flues and air inlets are frequently recommended, the ducts are relatively costly and space consuming and they are not adapted to automatic control. Systems using windows are the least desirable because they require frequent opening and shutting as the weather changes and can cause drafts which may lower milk production.

The increase in the confinement housing of cattle combined with the growing recognition of the important effect of climatic environment on livestock performance has stimulated producer interest in the possibilities of air conditioning.

At present, the cost of total air conditioning is considered too high in relation to the dollar return of the production gains for its use to be warranted for beef or dairy cattle except under unusual circumstances.

In cooperative Federal-State experiments at the Psychroenergetic Laboratory at the University of Missouri, researchers found that air conditioning might be profitable under the following set of conditions: if each cow gives at least 40 pounds of milk a day, the price is at least $6.00 a hundredweight, the daily average outside air temperature stays above 80° F., and the relative humidity stays above 65 percent for 60 or more days each year.

Where costs of air conditioning with refrigerated air would be too high to increase net returns to the farmer, other less costly measures for providing a more comfortable environment may give a partial answer. In California, an evaporative or "desert" cooler was used experimentally with some success to take advantage of the low summer humidity in reducing the temperature of the air. Improved ventilation through proper placement and design with an adequate insulation to protect animals from extreme temperatures also help improve an unfavorable environment and may increase profits when air conditioning would not pay.

Use of Water

Water also plays an important role in providing a favorable environment for confined livestock.

In experiments conducted by USDA and California scientists in the Imperial Valley, Hereford calves supplied with cool drinking water made better gains than those drinking uncooled water having an average temperature around 88° F. Brahman calves, a breed more adapted to warm climate than Herefords, apparently did not benefit from cool water.

Increased gains made by cattle as a result of cooling their drinking water were not sufficient to make refrigerative cooling economically feasible. However, the findings did point up the desirability of providing cool drinking water when it can be done economically--as, for example, by piping cool well water or spring water underground for short distances to the trough or storing it in insulated tanks.

Use of water sprinklers under shades also resulted in improved performance of cattle in the Imperial Valley studies. Similar results were reported in Louisiana. However, it appears doubtful that sprinkling the animals helps where the relative humidity is not low enough to permit heat loss from evaporation at surface temperatures of the animal.

Cooling the roof of shades by use of sprinklers also was found to be beneficial under western conditions. However, this practice is relatively expensive.

Besides helping to mitigate the effect of hot climate, adequate supplies of pure water are important for providing a sanitary environment for confined animals. (See pages 16 and 17 for more information on this subject.)

Adjusting Rations to Climatic Conditions

Adjusting rations to climatic conditions is another possibility for alleviating climatic stress. Since a larger percentage of low-grade roughage is transformed into heat in the process of digestion, it would be logical to expect that concentrates would be more suitable for feeding in hot weather than low-grade hay. Experiments have tended to bear this out. In cooperative Federal-State feeding experiments, in the Imperial Valley, for example, beef cattle fed one-third grain rations gained more rapidly than animals receiving such hay only--1.58 pounds a day for the grain eaters, 0.97 pounds a day for the hay eaters.

Information on the subject is available from a number of State Agricultural Experiment Stations, while more detailed reports of environmental research and its implications to beef and dairy cattle enterprises have been extensively reported in technical journals generally available in local libraries. A selected list of publications containing references to the effect of environment on beef and dairy cattle performance follows.

Environment of Animals, by T. E. Bond and C. F. Kelly. 1960 Yearbook of Agriculture (Yearbook Separate No. 3030). U.S.D.A.
Engineering the Farmstead, by J. W. Rockey and S. S. DeForest. 1960 Yearbook of Agriculture (Yearbook Separate No. 3032). U.S.D.A.
Finishing Beef Cattle, Farmers' Bulletin No. 2196. 1964. U.S.D.A.
Methods of Increasing Beef Production in Hot Climates, by N. R. Ittner, T. E. Bond, C. F. Kelly. California Agricultural Experiment Station. Bulletin No. 761. 1958.

FACILITIES

With larger herds of cattle confined to smaller space, facilities such as buildings, equipment, and layout for improving the environment of animals, saving labor, or permitting improved management practices take on added significance.

What buildings, layout, and equipment will be best adapted for economic production of milk and beef depends on many variables. Important among these are size of farm, local climatic conditions, age of the animals, local building costs, labor availability, and long-term objectives of the farmers.

Available research information can help farmers in selecting or adapting a plan suited to their individual needs. ARS and a number of States have studied layout, and space requirements, farm buildings, labor-saving equipment, and water and waste disposal.

Layout

Farmstead layout is an important consideration in the production of beef and milk and confined animals.

When beef or dairy cattle are taken off pasture and large numbers confined in a small area, the location and arrangement of farm buildings can be an important aid or a serious obstacle to the farmer's primary objective for going into confinement--namely, to reduce unit production costs. Having buildings in the right places can shorten distances and contribute to good management.

Livestock specialists and agricultural engineers emphasize the importance of a good layout adapted to the needs of the particular beef or dairy cattle enterprise. But they also recognize that few confinement-farming enterprises can be built new from a grand plan.

Farmers usually are faced with adapting or rebuilding their old setup or starting with small enterprises which can be enlarged when sufficient capital is available. This calls for a long-term planning so that immediate improvements will fit into future objectives. Buildings and plans should be as flexible as possible so that they can be adapted readily to changing needs.

Each farm presents a different layout problem. However, certain general principles developed through research by the United States Department of Agriculture and the various States should help the individual producer develop a plan suited to his needs and purposes.

The choice of site and placement of buildings and facilities can affect the environment for confined animals. Space requirements for optimum performance of animals under various climatic conditions is one phase of environmental study closely connected with layout planning. For example, it takes less space in lounging and holding pens per animal to provide a favorable climatic environment in cold weather than in hot weather, provided the ground is paved, properly drained, and kept clean.

Sanitation is another important consideration in layout planning. This includes availability of adequate supplies of pure water for drinking and cleaning as well as adequate arrangements for drainage and cleaning.

Need to arrange buildings with regard to labor saving has also been mentioned in an earlier section.

Dairy Layout

To put planning on a more scientific basis, ARS and various States have studied the efficiency of different dairy arrangements and developed plans adapted to the efficient production of high quality milk.

Changing to a loose housing system of dairy operation is one way in which many farmers have successfully met the problem of handling larger numbers of dairy cattle efficiently with a minimum investment in building and labor.

Loose housing is not new. However, mechanical feeding or self feeding and improved methods of handling manure and cleaning the feeding and resting areas have helped to reduce the labor involved in this system of housing.

Despite the relatively open shelters used in the loose housing system, cows do not suffer from the cold because they develop thick coats and have protection from rain and snow. In mild climates where the animals can be outside all year, no shelter may be necessary--only shade and milk area buildings. (See section on Farm Buildings for additional discussion of loose housing, p. 13-15.)

Drylot Layout

The increase in drylot feeding of beef and dairy cattle in mild climates has been spurred by the relatively low initial costs for building drylot feeding corrals and the opportunities they afford for handling large numbers of animals and great quantities of feed and other materials smoothly and efficiently.

The smooth flow of materials has been a major objective in layout design. This can only be assured if the corrals are engineered as a part of an overall production plan to save labor and avoid bottlenecks. Considerable basic information and typical layouts for efficient feeding corrals have been developed and tested. Many recent studies--already noted--have emphasized environment.

Recent studies have also placed considerable emphasis on sanitation. Since the sanitary problem varies with the climate, good drylot design takes into account the weather conditions under which the facility will be used--whether under summer or winter conditions.

Research findings show that within certain limits comfort and sanitation in hot climates are improved by a high area-to-animal ratio. However, in some hot dry areas, particularly where there is air inversion, dust can be a feedlot problem which is apparently aggravated if the area-to-animal ratio is higher than necessary for the comfort of the animals. Experiments have shown that gains of beef cattle were not reduced with space allowances as low as 90 square feet per animal even under hot weather conditions such as at El Centro, Calif. And where dust is a particular problem, some operators have found it desirable to reduce the area per animal below 90 square feet so that the urine will be sufficient to wet the earth and hold down dust.

The tendency of many drylot operators is to crowd more animals into the same space during cold weather. There is less danger of heat stress then, but poorer drying conditions. The better choices, then, are to keep cattle numbers down to the reasonable capacity of the lot, or else to enlarge the corrals if practical or pave enough area to keep the cattle out of the mud.

In addition to space, many other factors need to be taken into account in designing drylots to keep animals clean. The shape, size, location, and equipment are important.

Rectangular corrals are most frequently used for drylot feeding both beef and dairy cattle, particularly large herds of 1,000 or more. However, pie-shaped corrals have some definite labor-saving advantages for herds up to 1,000 beef cattle or lactating cows.

Most pie-shaped layouts for beef or dairy corrals have near-circular perimeters. These are usually easier to clean than corrals with rectangular perimeters.

The tendency of cows to cluster around the narrow end of the corral near milking time can be a distinct disadvantage in pie-shaped dairy layouts in winter. But with a paved standing area in this location, the pie-shaped corral is a good arrangement for summer.

General information and typical layouts for drylot enterprises for dairy and beef cattle in hot and cold areas have been published by USDA and a number of States. A list of some publications in this field follows:

Loose-Housing System for Dairy Cattle. Miscellaneous Publication No. 859. 1961. U.S.D.A.

The Herringbone Milking System: Economic Appraisal, Labor Efficiency Analysis and Adjustment Possibilities. Production Research Report No. 45. 1960. U.S.D.A.

Improved Methods and Facilities for Commercial Cattle Feedlots. Marketing Research Report No. 517. 1962. U.S.D.A.

Milking Plant, Herringbone Type--Plan No. 5868.[1] Miscellaneous Publication No. 818 only for sale at 5¢ by Superintendent of Documents, Government Printing Office, Washington, D.C., 20402. 1960. U.S.D.A.

Milking Plant, U Type--Plan No. 5736.[1] Miscellaneous Publication No. 817. 1960. U.S.D.A.

Corral and Feed Lots for Beef Cattle--Plan No. 5920.[1] Miscellaneous Publication No. 895. 1962. U.S.D.A.

Farm Buildings

Design of farm buildings is particularly important for the efficient production of milk and beef with confined cattle. With more livestock and materials to be handled in a small area, properly designed and located structures can contribute to production efficiency. The right buildings can do this by shortening distances, permitting use of labor-saving equipment, providing better working conditions, and facilitating the adoption of better management practices, as well as by contributing to a favorable environment.

Barns designed for diversified farming are seldom adapted to producing beef and dairy products with confined cattle. Therefore farmers who switch to a confinement type of operation usually need to plan new farm structures or to remodel their old multi-purpose buildings for the adequate housing and handling of larger numbers of cattle under confinement conditions.

The desire to accommodate a larger herd is, in some instances, the primary objective of farmers in changing their old stanchion-type barns to loose-housing structures. However, the majority of dairy farmers continue to use the traditional stanchion-type barn. For example, a study of some 4,000 Wisconsin dairy farmers who remodeled or built barns in 1960 showed that 94 percent remodeled or built stall barns and only 6 percent converted to or built loose-housing structures.

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[1] The detailed working plans are distributed by the States. Usually there is a small charge for the plans.

Nevertheless, the loose-housing system for confinement dairying has been popular with many producers who have tried it. Some plans for a shed, milking parlors, and related buildings are included among the publications listed at the end of this section.

Also, changes in herd size and feeding which have accompanied the increased confinement of cattle have affected requirements for feed-storage structures. But here, again, the best type of structures depends on many variables, including the size of the operation, the type of ration, and how much--if any--of the stored feed is raised on the farm.

In some large feedlots on the West Coast, for example, the storing and mixing of feed for herds of a thousand or more cattle require a factory-like setup. But even in much smaller confinement operations, horizontal bunkers with self-feeding fences for silage and chopped forage are commonly used to replace or supplement small silos used for non-confinement set-ups.

Although the work pattern of the operator makes a great difference in the amount of time and labor spent in milking and other dairy chores, the type of arrangement significantly influences the efficiency of operation. For example, recent studies have shown that herringbone milking parlors have definite labor-saving advantages.

Experiments conducted by ARS in cooperation with the California Agricultural Experiment Station with herringbone layouts of various sizes indicate that double-four, double-five, and double-six stall parlors are suitable for herds up to 150 cows. Parlors of double-eight and double-ten size are required for herds between 150 and 400, while two parlors of this size are suggested as probably preferable to one larger parlor when the size reaches 400 or more. The two-parlor arrangement helps avoid delays in the holding-washing pens, movement lanes, and other stages of the milking routine.

From a labor-efficiency viewpoint, an ARS researcher concluded that a double-five herringbone arrangement is best for one man working at a pace of 125 percent of normal.

Since each farm presents a particular problem, it is impractical to have a few simple sets of building blueprints to fit most confinement dairy or beef production operations with little or no alteration. However, research by ARS and the various States has developed basic information that has been widely used in designing buildings for better climatic environment, for saving labor, and for good management under widely varying conditions. In addition, plans for farm buildings designed to adequately meet the climatic and structural stresses of different parts of the country have been developed by ARS and the various States and distributed through the State Extension Services.

A selected list of USDA publications and building plans issued cooperatively by ARS and the various States and available through the States follows:

Economic and Functional Characteristics of Farm Dairy Buildings, by R. N. Van Arsdall, D. B. Ibach, and Thayer Cleaver. Bulletin 570. University of Illinois Agricultural Experiment Station in cooperation with U.S.D.A. 1953.

A Loose Housing System for Dairy Cattle. Miscellaneous Publication No. 859. 1961. U.S.D.A.

Pole Building Construction--Type B.--Plan No. 5831.[2] Miscellaneous Publication No. 750. 1958. U.S.D.A.

Hay Shed for Self-Feeding--Plan No. 5847.[2] Miscellaneous Publication No. 772. 1958. U.S.D.A.

Shed Roof Construction--Plans Nos. 5855; 5856; 5858.[2] Miscellaneous Publication No. 806. 1959. U.S.D.A.

Roofed Bunker Silo with Optional Sheds--Plan No. 5848.[2] Miscellaneous Publication No. 783. 1959. U.S.D.A.

Bunker Silo, Types B, C, and E--Plans Nos. 5829, 5843, and 5865.[2] Miscellaneous Publications Nos. 784, 1959; 781, 1959; 815, 1960, respectively. U.S.D.A.

Equipment

The importance of wise selection and use of choring equipment has been magnified by the trend toward confinement of beef and dairy cattle. Equipment for efficiently preparing and delivering feed to the animals and equipment for moving large quantities of bedding, for disposing of manure, and for cleaning areas used by cattle gain importance when cattle are confined. With larger dairy herds, equipment for milking and handling the milk safely, efficiently, and in conformance with sanitary standards is essential for competitive production of high-grade dairy products.

The use of fans, sprinklers, water coolers, and air conditioning was discussed in the section on environment.

The trend to larger herds and confinement housing has helped justify the purchase of environment-improving and labor-saving equipment for many farmers. With more animals on the spot to use such equipment, the investment per animal in equipment is lower. This is dramatically demonstrated in large, factory-like beef and dairy operations that have developed near big cities, where land is scarce and costly and real estate taxes are high. But the same logic applies to small one-man operations which require labor-saving equipment to enable the owner to enlarge his herd sufficiently to continue producing in a competitive market. However, it is possible to overmechanize by wastefully supplanting available manpower with costly machines.

Agricultural engineers recommend developing an overall, long-term operations plan in advance, so that equipment can be purchased, placed, and used as part of a unified production system.

Researchers of ARS and the State Agricultural Experiment Stations are continually developing methods and machines for handling livestock and materials more efficiently. As information is uncovered by research, it is released. Some of the information is simple and specific enough for incorporation in plans that mechanically minded farmers can use or adapt to their needs. Other, more technical data help equipment manufacturing firms serve farmers better.

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[2] The detailed working plans are distributed by the States. Usually there is a small charge for the plans.

The type of feeding equipment best adapted to a particular farm is affected by many variables such as the kind of feed used, type of storage structure, size of the herd, and management objectives of the operator.

For example, size of the herd determines whether it would be cheaper and more efficient to use an augur type of mechanical bunk feeder or self-unloading wagons. Studies by ARS and the States show that the augur type of feeding equipment is efficient and easy to install when 250 to 300 animals are fed at one time. With large operations of 1,000 head or more, premixing the feed and delivering it by an unloading wagon is more efficient.

The need for a maximum return from the feed investment has also affected requirements for feed-handling equipment. Changes in the type and form of feed used in rations is one such factor that needs to be considered. The greater use of concentrates, corn silage, and low-moisture silage have implications for feed-handling equipment. One of the considerations motivating research on pelleted feed is the greater ease in handling it. Similarly the greater precision in the formulation and measuring of rations with a view to getting the highest production in meat or milk per dollar invested in feed has also influenced equipment needs. To help meet this need, ARS and a number of States have cooperated in developing equipment for accurately measuring and mixing feed.

Among the publications on equipment related to confinement housing are the following:

Automatic Feeding Equipment for Livestock and Poultry. Farmers' Bulletin No. 2198. 1964. U.S.D.A.

Feedlot and Ranch Equipment for Beef Cattle. Farmers' Bulletin No. 1584--Rev. 1963. U.S.D.A.

Engineering the Farmstead, by J. W. Rockey and S. S. DeForest. 1960 Yearbook of Agriculture (Yearbook Separate No. 3032). U.S.D.A.

Handling Silage and Concentrates for Beef Cattle in Drylot. Circular 714. University of Illinois in cooperation with U.S.D.A. 1954.

Homemade Milking Stall, Side Entering Type--Plan No. 5846.[3] Miscellaneous Publication No. 790. 1959. U.S.D.A.

Mangers and Feeding Floors for Dairy and Beef Cattle--Plan No. 5837.[3] (Miscellaneous Publication not available.) 1959. U.S.D.A.

Watering Trough (Continuous Flow) for Cattle--Plan No. 5909.[3] Miscellaneous Publication No. 898. 1962. U.S.D.A.

Manure Disposal Facilities

How to dispose of accumulated manure and urine in an efficient and sanitary manner is an important concern of all types of beef and dairy operations. But the problem is aggravated in confinement enterprises in which the cattle and their waste are concentrated in a small area rather than spread out on range or pasture. This is particularly true in the case of large-scale feeding corrals or dairy enterprises located in thickly populated areas adjacent to big cities.

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[3] The detailed working plans are distributed by the States. Usually there is a small charge for the plans.

Need for layout and facilities that will simplify the sanitary disposal of cattle manure and urine has already been touched on in earlier sections of this report. The need for adequate supplies of water and equipment to do the job has also been brought out. But what to do with the wastes when they have been removed from barns and corrals is a problem that is increasingly plaguing livestock operators.

The traditional practice of spreading manure on fields or pastures is difficult where sufficient land for spreading is not available. In such cases some other means of disposing of or storing the manure--such as underground pits or lagoons--becomes necessary.

Use of Lagoons

Use of lagoons for disposal of livestock and poultry manure has increased rapidly in recent years. Scientists of ARS and a number of States have done considerable research in the area. These investigations have established the value of properly designed lagoons where the soil and other conditions are favorable for their use. However, ARS researchers point out that lagoons do not offer a magic cure-all for the livestock waste disposal problem. For example, the soil in some areas is too porous. And in some areas, the danger of contamination from seepage or runoff precludes the safe use of lagoons for livestock waste.

In many cases, however, well-constructed and managed lagoons have proved an efficient method of holding or disposing of waste from confined cattle. While size and type of lagoon required will obviously vary with the operation, some general principles have been developed by research. A few guidelines based on findings of ARS engineers follow:

Choice of a lagoon site should take into consideration soil percolation rate, possibility of contamination of wells, availability and cost of land, direction of the prevailing wind, nearness of the lagoon to animals served, and need for diversion dams or ditches.

Size of lagoon needed may be determined in either of two ways: (1) On a volumetric basis, since 1 cubic foot of water will stablize 0.01 pound of manure per day; or (2) on a surface area basis, using the population equivalent values set up in a Waste Disposal Feasibility study by the National Institutes of Health.

For successfully operating a lagoon, certain do's and don'ts are recommended: (1) Avoid floating material of any kind as this reduces surface absorption of oxygen from the air and obstructs light which hasten decomposition; (2) Avoid overloading, as this results in an odorous and an unsightly condition, (3) Avoid intermittent loading, as this changes the population of decay-causing microorganisms and lowers efficiency of the lagoon; (4) Mow weeds at lagoon edge to keep down the mosquito and rodent population but do not permit clippings to fall into the lagoon (see first recommendation).

Slotted Floors

Increasing use of slotted floors in swine shelters to simplify the waste disposal problem has raised some speculation about the value of this type of flooring for cattle continuously confined in a small space.

Slotted floors have been used to some extent in Europe with confined cattle but the practice has been tried only to a very limited degree in this country--mostly in a few areas in which farmers are confronted with the need of keeping their dairy cattle confined in closed structures for protection against extreme cold.

ARS has not done any studies on the use of slotted floors for cattle, although some experiments on their use with swine are under way. And they are being tried out by some individual farmers and researchers in various parts of the country.

A simply designed slotted floor and lagoon-type waste disposal system was successfully used in a bull feeding barn during tests started in 1961 at the Colorado State University Experiment Station, for example. Investigators found that this kept the bulls dryer and cleaner than the old system of bedding. The bulls did not hesitate to go onto the floor and no unusual lameness or health problems were noted.

The system consisted of concrete trenches, each about 125 feet long and 6 feet wide, which dropped gradually along their length for draining and flushing. The system operated efficiently at most times but freezing caused some trouble. This problem was overcome by letting some water circulate in the pits and completely draining them whenever ice formed over the top. This caused the ice to drop down and break in pieces.

Slotted floors are now being used in free stall barns.

LOOKING AHEAD

Barring unforeseen developments, the outlook is for a continuing increase in confinement rearing of beef and dairy cattle. The forces that caused many beef and dairy cattle owners to change to a confinement type of operation in the past are still pressuring in the same direction.

The increase in the size of farms, increased specialization, rising land prices in the vicinity of cities, labor shortages, the growing emphasis on scientific feeding and on environmental controls for optimum performance of livestock, and the need for reducing unit production costs are all prominent in present agricultural thinking. And all appear likely to continue to contribute to the shift toward large confinement type beef and dairy cattle operations.

Even in the case of small, owner-operated farms, the need to cut down unit production costs by increasing the herd size without a corresponding increase in paid labor or land may be met in some instances by confining the animals and bringing their rations, both home-grown and purchased, to them.

As more precise information is continually being developed about the effect of the varying elements of the environment on the performance of beef and dairy cattle and measures for improving unfavorable conditions are devised and tested, opportunities for increasing the productivity of confined cattle will increase. Obviously, however, for a measure such as air conditioning to be economically practicable in a particular instance, the value of the increased production of beef or milk must be greater than the cost of installing and maintaining the environment-control equipment.

Research is going forward with the aim of reducing the hand work connected with livestock choring and materials handling to a level more comparable with the reduction that has occurred in field labor through mechanization.

Looking toward the more distant future when the population will presumably be much larger and the demand for quality beef and dairy products correspondingly greater, agricultural engineers foresee the possibility of greatly increased confinement of cattle in well insulated buildings. With scientifically controlled environmental conditions, considerably less space per animal would be required and production increased. Increased emphasis on scientifically adapting rations to environmental conditions and to the age of the animal and quality objectives is also expected to accompany the effort to lower unit costs of producing milk and beef with confined cattle. Other feeding trends which are likely to gain impetus from future increases in confinement of cattle include a growing emphasis on the harvesting and handling of forage crops in a way that will provide the maximum nutritional value and the increased use of pellets and concentrates or even some form of super-concentrated feed to reduce the volume of feed to be handled and manure to be disposed of.